Weed Instrument
Fiber Optics

EOTec 2000 ControlNet
User Manual

Communication Modules for
ControlNet Physical Media Layer

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ControlNet International
The Association for Users of ControlNet

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Standards and Safety

The EOTec 2000 ControlNet Modules from Weed Instrument have been designed to meet the following standards.

	The EOTec 2C20, 2000 Series DC power supplies, and 2000 Series optical modules are all UL/cUL listed and FM approved for use in Class I, Division 2, Groups A, B, C, D T4(-40°C To +85°C)
	And meets the requirements for CE marking per EN61326-1
	The EOTec 2000 Series AC power supplies are UL/cUL Recognized components (-40°C To +85°C)
	Install EOTec ControlNet Modules in accordance with local and national electrical codes.
	Lightning Danger: Do not work on equipment during periods of lightning activity.

Table of Contents

1

Introduction

This manual describes the uses for the EOTec 2C20, a *ControlNet™ communications module specially designed for connecting ControlNet devices on the Physical Media Layer in industrial field applications.

ControlNet is swiftly being adopted by the industrial automation and control industry. Industrial applications often demand rugged, robust equipment that can provide high reliability in settings far removed from a comfortable, climate-controlled office environment.

Devices attached to a network normally cannot tell what is happening elsewhere on the system. As a result, the responsibility for monitoring the network must fall on the ControlNet communication equipment that connects these devices. Real-time alarms are a vital feature to inform system administrators and operators when a problem exists on the network.

Introducing the EOTec 2000 Modular ControlNet Stack

The EOTec 2000 Modular ControlNet Stack is designed to give reliable operation in harsh industrial environments. As shown in figure 1-1, Weed Instrument provides a modular solution called a ControlNet Stack for addressing various communications topologies. Create the ControlNet Stack that meets your needs; for single point-to-point connections, cascade or extend this into a daisy-chain, or branch out into a star configuration. Or you can combine all three topologies in one network. The 2C20 module can be used alone for electrical communications on a ControlNet trunk line or optical modules can be added for greater distances between your ControlNet devices.

Fiber optic technology provides many advantages for industrial control applications. These include EMI/RFI immunity, the ability to run fiber optic cable through hazardous areas, and the ability to connect long distance communication links.

Each EOTec ControlNet Stack comes with LED indicators for local determination of communication failures. In addition, Weed offers options such as redundant power supplies or power supplies with alarm relay contacts that can be wired to provide failure information at a remote location. Also, all fiber optic models have optional diagnostics ports ("2Dxx" series) to provide a 4 to 20mA diagnostic output for use in determining optical power level (light intensity) of any or all glass fiber cables.

* ControlNet is a registered trademark of ControlNet International, Ltd

EOTec 2000 ControlNet Stack Options
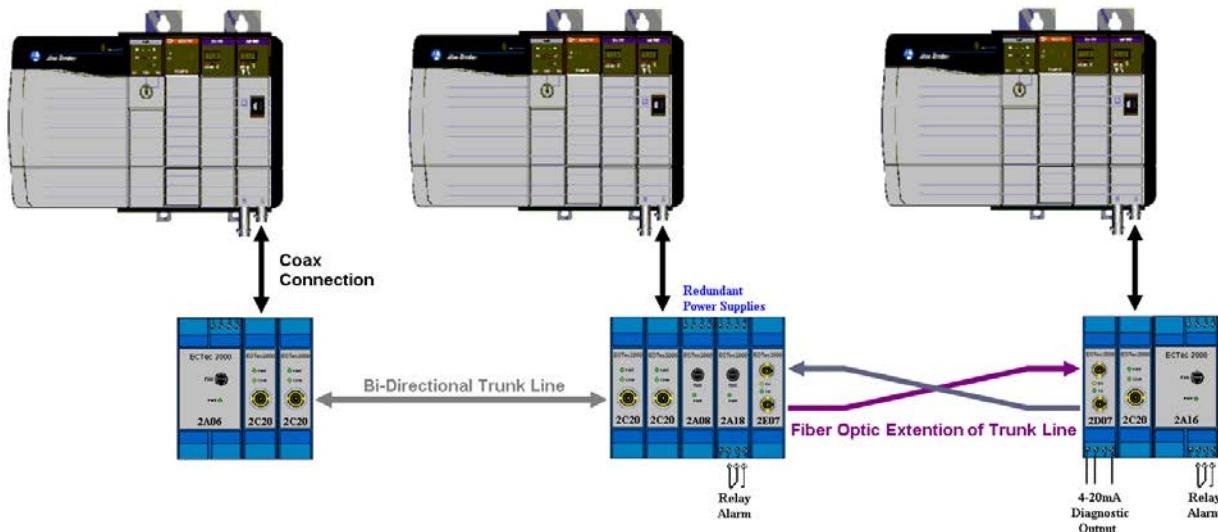
Figure 1-1

In a <u>redundant topology</u>, no matter where in the network that communication is cut, all devices connected to a node in the network can still communicate with each other. In figure 1-2, the active path (Channel A) between two stacks is broken, but the backup path (Channel B) has the information to maintain the integrity of your network.

**Dual Channel Communication**
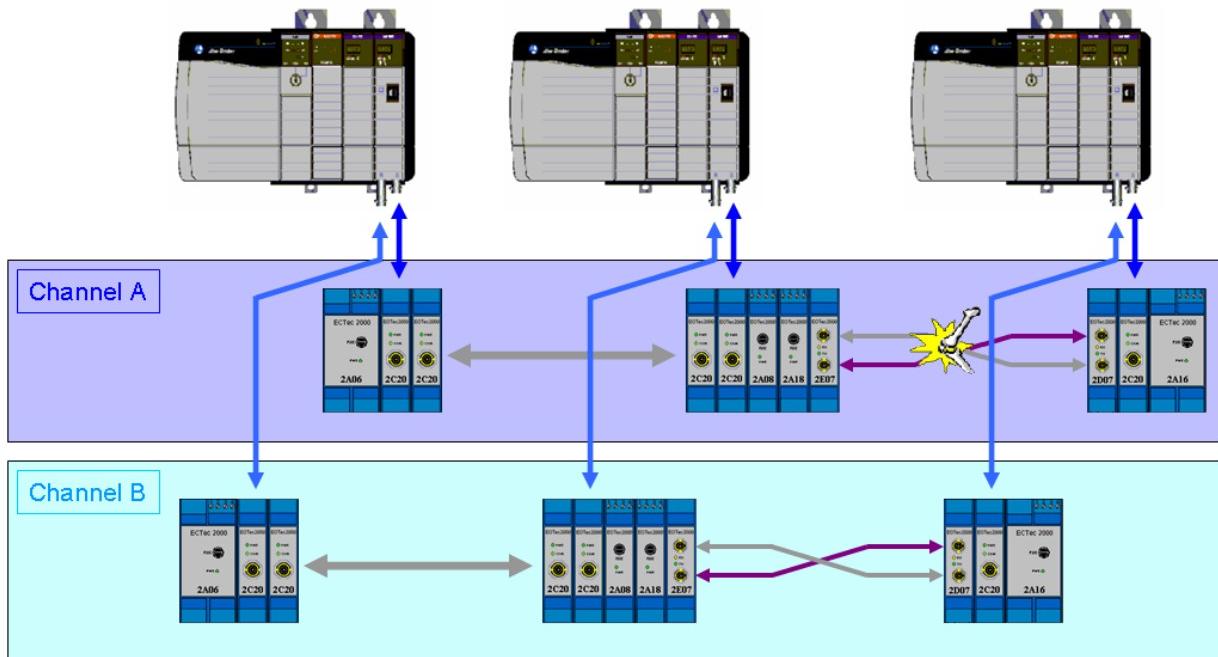
Figure 1-2

Feature Overview

EOTec 2000 ControlNet Stacks can support both Multi-Mode and Single-Mode with optical modules. Optical modules support either 850nm or 1300nm wave lengths. EOTec Optical models support maximum fiber optic cable lengths from 3km to 20km*.

Fiber Optic Module	2E07 / 2D07	2E10 / 2D10	2E09 / 2D09	2E36 / 2D36	2E46 / 2D46
Fiber Operating Wavelength	850nm	850nm	1300nm	1300nm	1300nm
Fiber Diameter	62.5/125µm	62.5/125µm	62.5/125µm	9/125µm	9/125µm
Fiber Type	Multimode	Multimode	Multimode	Single-Mode	Single-Mode
Typical Wavelength Attenuation	3.5dB/km	3.5dB/km	1.5dB/km	0.5dB/km	0.5dB/km
Optical Power Budget	12dB	17dB	12dB	10dB	16dB
Estimated Max. Distance (km)	3.429	4.857	8.000	20.000	20.000*
Estimated Max. Distance (mi)	2.130	3.017	4.970	12.427	12.427*

* The 2E46 is capable of much longer distances, but is constrained by the ControlNet maximum network limit.

Appendix B, *EOTec 2C20 Product Series*, includes more information on optical models.

Your EOTec ControlNet modules may require jumper configurations. All ControlNet communication modules have easily selectable jumpers to meet your unique network configuration. Each module must have a different address to allow communication across the Interconnection BUS, but the modules can be connected in any order when integrated into a communication stack for your specific needs. See Device Jumpers for the proper jumper settings for your ControlNet modules.
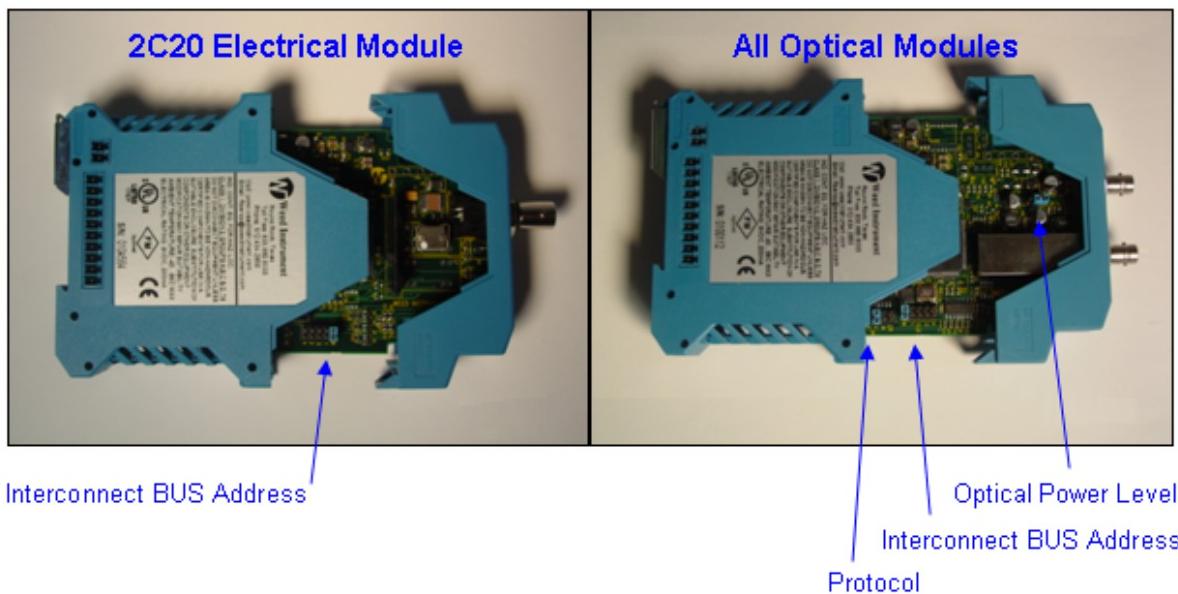
Optional Accessories

Contact your Weed sales representative to order any of these accessories.

- Fiber optic expansion modules
- Redundant power supplies
- Power Alarm Relays
- Optical Power Level Diagnostic Output Ports

2

EOTec ControlNet Hardware

This chapter describes the EOTec 2C20 and how it is designed to give reliable operation in harsh industrial environments. The 2C20 is a direct electrical connection to your ControlNet hardware and is the heart of the Weed ControlNet Stack. It can be used to link together a coax network or be teamed with fiber optic modules to provide noise immune communications over greater distances.

Designed for Industrial Applications

➢ **High Performance Reliable Technology**
   o Fully compliant with ControlNet specification
➢ **Support for Multiple Network Structures**
   o Point-to-point (Branch)
   o Daisy-chain structure (Linear)
   o Star structure
   o Tree structure
➢ **Industrial Design for High Reliability**
   o Modular, flexible, scaleable
   o Operating temperature range -40 to +85C
   o FM approved for Class I, Div 2, Groups A, B, C & D
   o Standard 35 mm DIN-rail mounting
➢ **Optional accessories available**
   o Fiber optic expansion modules (Multi-mode and Single mode)
   o Redundant power supplies
   o Power alarm relays
   o Optical power level diagnostic ports

EOTec Power and Alarm Connections

The 2C20 interface module can be powered from the same DC source that is used to power other Weed I/O devices. Power is applied by connecting an EOTec Power Supply Module to the backplane of the EOTec 2C20 Electrical Interface Module. Adding an additional power supply (redundant supply) module prevents possible down time resulting from power loss, and is available in several models from Weed Instrument.

Model		Specifications	
2A06		**Power Requirements:**	90 to 260VAC, 47/440Hz at 400mA, 120 to 260VDC at 400mA
		Output to Integrated BUS Interconnections:	Nominal 9Vdc, 1.1A
		Screw Terminals:	Pluggable, cage-clamp, screw terminal block Accept 12 to 24 AWG
		Input Fuse:	250V, 400mA, slow-blow 5 x 20mm Littlefuse # 218.400
2A08		**Input Power Range:**	15 to 30VDC at 400mA
		Output to Integrated BUS Interconnections:	Nominal 9Vdc, 1.1A
		Screw Terminals:	Pluggable, cage-clamp screw terminal block accepts 12 to 24 AWG
		Input Fuse:	400mA, slow blow, 5 x 20mm Littlefuse # 218.400
2A16		**Power Requirements:**	90 to 260VAC, 47/440Hz at 400mA, 120 to 260VDC at 400mA
		Output to Integrated BUS Interconnections:	Nominal 9Vdc, 1.1A
		Screw Terminals:	Pluggable, cage-clamp, screw terminal block Accept 12 to 24 AWG
		Relay Contacts:	Form-C (SPDT), 175Vdc, 1A Continuous, 0.25A Switching
		Input Fuse:	250V, 400mA, slow-blow 5 x 20mm Littlefuse # 218.400
2A18		**Input Power Range:**	15 to 30VDC at 400mA
		Output to Integrated BUS Interconnections:	Nominal 9Vdc, 1.1A
		Screw Terminals:	Pluggable, cage-clamp screw terminal block accepts 12 to 24 AWG
		Relay Contacts:	Form-C (SPDT), 175Vdc, 1A Continuous, 0.25A Switching
		Input Fuse:	400mA, slow blow, 5 x 20mm Littlefuse # 218.400

Table 2-1

The various power supplies are wired as shown below in figure 2-1. In addition to power, the 2A16 and 2A18 have an alarm relay. Connections to Form-C (SPDT) relay contacts are available at the bottom-front of the module. The pluggable, screw terminal block connections are as follows:

Power	2A06/ 2A16	2A08/ 2A18
1	AC Line or DC(-)	N/C
2	N/C	24Vdc (+)
3	N/C	Return (-)
4	AC Neutral or DC(+)	Earth Gnd

| Relay	Connections
1	No connection
2	Normally Closed (no power)
3	Common
4	Normally Open (no power)
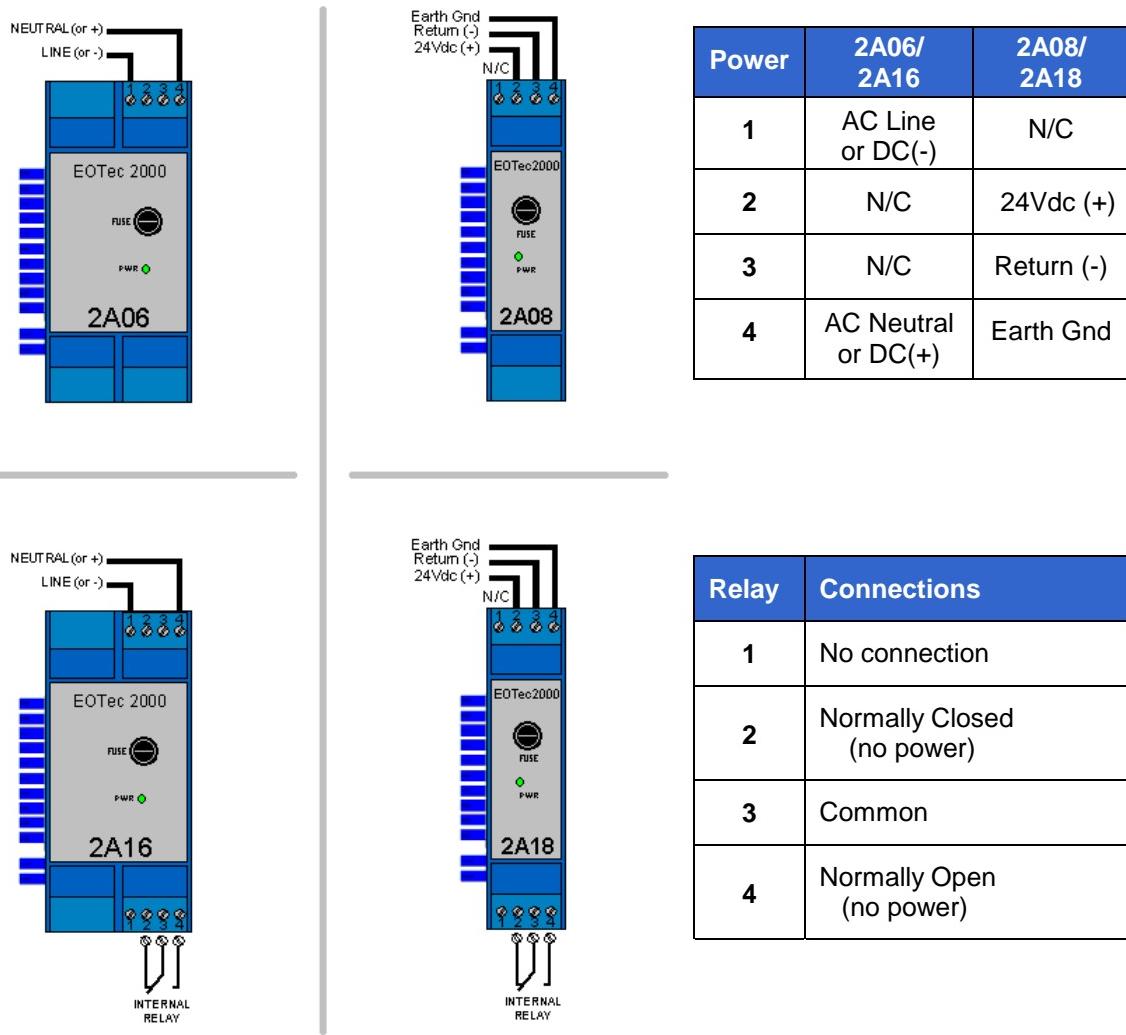
Figure 2-1

EOTec Fiber Optic Modules

The 2C20 electrical interface module can be teamed with optical modules. This allows communications over much greater distances and prevents the introduction of noise along the transmission path. Adding additional modules provides users a string of communication stations (daisy-chain) or communication to an array of stations (star) from a centrally located "hub".

Weed offers 6 various optical modules to meet your unique ControlNet needs, but all are designed for reliable operation in harsh industrial environments:

➢ **Transparent Copper to Fiber Conversion**
  o Up to 4 optical modules per stack
  o Single/Multi-mode conversion possible
  o Optional real-time diagnostic output (4-20 mA)
  o 850nm and 1300nm wavelengths
  o High/Low power setting
  o Long lifetime – Class 1 LED
➢ **Support for Multiple Network Structures**
  o Point-to-point (Branch)
  o Daisy-chain structure (Linear)
  o Star structure
  o Tree structure
➢ **Industrial Design for High Reliability**
  o Modular, flexible, scaleable
  o Operating temperature range -40 to +85C
  o FM approved for Class I, Div 2, Groups A, B, C & D, T4
  o Standard 35mm DIN-rail mounting
➢ **Optional accessories available**
  o Optical power level diagnostic port

To meet unique customer needs Weed offers the following in tables 2-2a, 2-2b. For more inclusive specifications, see Technical Specifications. Compatibility with other manufacturer's ControlNet optical links is neither expressed nor implied.

Also, consult sections 'Understanding EOTec Fiber Modules' and 'Understanding Fiber Attenuation' to help select the module that is correct for your application.

Model		Specifications	
2E07		**Optical Wavelength:**	850nm, LED
		Fiber Compatibility:	62.5/125μm, Multimode 200/230μm, Multimode
		Optical Dynamic Range (utilizing fiber size)	
		62.5/125μm:	12dB
		200/230μm:	21dB

Table 2-2a

Model	Specifications	
2E09	Optical Wavelength:	1300nm, LED
	Fiber Compatibility:	62.5/125μm, Multimode
	Optical Dynamic Range (utilizing fiber size)	
	62.5/125μm:	12dB
2E10	Optical Wavelength:	850nm, LED
	Fiber Compatibility:	62.5/125μm, Multimode 200/230μm, Multimode
	Optical Dynamic Range (utilizing fiber size)	
	62.5/125μm:	17dB
	200/230μm:	23dB
2E36	Optical Wavelength:	1300nm, LED
	Fiber Compatibility:	5 to 10μm Optical Core, Single-Mode
	Optical Dynamic Range (utilizing fiber size)	
	9/125μm:	10dB
2E46	Optical Wavelength:	1300nm, LED
	Fiber Compatibility:	5 to 10μm Optical Core, Single-Mode
	Optical Dynamic Range (utilizing fiber size)	
	9/125μm:	16dB

Table 2-2b

EOTec Optical Diagnostic Modules

The 2C20 electrical interface module can also be teamed together with optical diagnostic modules. Diagnostic modules have the same optical characteristics of their "E" series counterparts, but also have an internally powered 4 to 20mA diagnostic output which provides an indication of the received optical power level (light intensity) from the fiber. The output is calibrated such that the receive sensitivity threshold (the minimum optical power level needed for operation) corresponds to the 4mA point. The 20mA point corresponds to the guaranteed minimum optical power output (on the high "H" jumper setting) available directly at the Transmit optical port of any Optical Diagnostic Module. Adjustments to the factory settings are NOT recommended.

Connections to the diagnostic output are made via the pluggable screw terminal block at the bottom-front of the module and are as shown in figure 2-2 below.

N/C ⎯⎯⎯⎯ Shield (Protective Earth Ground)
⎯⎯⎯⎯ 4-20mA loop return (-)
⎯⎯⎯⎯ 4-20mA loop positive (+)
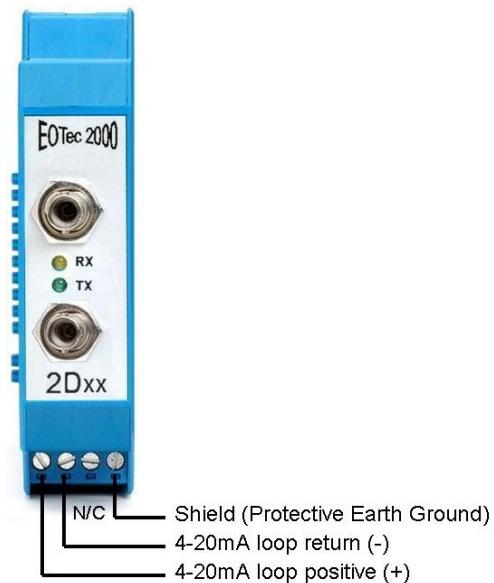
Figure 2-2

The fiber link should operate properly until the diagnostic output reaches the 4mA point. Below the 4mA point, the light loss on the fiber is so severe that the module will no longer function. A reading of 20mA or greater indicates that the fiber losses are very low. By comparing the analog reading of the diagnostic output to the Output Graphs shown in tables 2-3a and 2-3b, the amount of optical loss budget remaining before failure occurs can be determined.

NOTE: The diagnostic output will only indicate the optical signal strength if there is optical data being transmitted over the fiber. If data transmissions over the fiber cease (as with no network input to the module, a disconnected or broken fiber), the diagnostic output will drop to 4mA or below.

Model	Specifications	Output Graph
2D07	**Optical Dynamic Range (Optical Power Loss Budget):** 12dB minimum **Typical loss at 850nm for 62.5/125µm Multi-mode Fiber:** 3.5dB/km (1.07dB/1000ft) **Typical Loss at a Fiber/Fiber Junction (Fiber Patch Panel):** 1dB **Graph:** Indicates the optical loss budget available based on the output current indicated. **Example:** An 8mA output indicates that 7dB of additional optical power loss will be required before the optical signal will no longer be received.	 **2D07 Optical Module** **Analog Output Reading vs. Loss Budget**
2D09	**Optical Dynamic Range (Optical Power Loss Budget):** 12dB minimum **Typical loss at 1300nm for 62.5/125µm Multi-mode Fiber:** 1.5dB/km (0.46dB/1000ft) **Typical Loss at a Fiber/Fiber Junction (Fiber Patch Panel):** 1dB **Graph:** Indicates the optical loss budget available based on the output current indicated. **Example:** An 8mA output indicates that 7dB of additional optical power loss will be required before the optical signal will no longer be received.	 **2D09 Optical Module** **Analog Output Reading vs. Loss Budget**
2D10	**Optical Dynamic Range (Optical Power Loss Budget):** 17dB minimum **Typical loss at 850nm for 62.5/125µm Multi-mode Fiber:** 3.5dB/km (1.07dB/1000ft) **Typical Loss at a Fiber/Fiber Junction (Fiber Patch Panel):** 1dB **Graph:** Indicates the optical loss budget available based on the output current indicated. **Example:** A 12mA output indicates that 14dB of additional optical power loss will be required before the optical signal will no longer be received.	 **2D10 Optical Module** **Analog Output Reading vs. Loss Budget**

Table 2-3a

Model	Specifications	Output Graph
2D36	**Optical Dynamic Range (Optical Power Loss Budget):** 10dB minimum **Typical loss at 1300nm for 9/125µm Single-mode Fiber:** 0.5dB/km (0.15dB/1000ft) **Typical Loss at a Fiber/Fiber Junction (Fiber Patch Panel):** 0.5dB **Graph:** Indicates the optical loss budget available based on the output current indicated. **Example:** An 8mA output indicates that 5dB of additional optical power loss will be required before the optical signal will no longer be received.	 2D36 Optical Module Analog Output Reading vs. Loss Budget
2D46	**Optical Dynamic Range (Optical Power Loss Budget):** 16dB minimum **Typical loss at 1300nm for 9/125µm Single-mode Fiber:** 0.5dB/km (0.15dB/1000ft) **Typical Loss at a Fiber/Fiber Junction (Fiber Patch Panel):** 0.5dB **Graph:** Indicates the optical loss budget available based on the output current indicated. **Example:** An 8mA output indicates that 10.5dB of additional optical power loss will be required before the optical signal will no longer be received.	 2D46 Optical Module Analog Output Reading vs. Loss Budget

Table 2-3b

Fiber Optic Cable Lengths

The quality of the fiber cable determines the maximum distance you can achieve. Consult your local distributor for attenuation specifications prior to purchasing your fiber media components. EOTec 2000 ControlNet optical modules are designed for use with either multi-mode or single-mode optic fiber. The wavelength used for each module is either 850nm or 1300nm. Table 2-4 below, provides estimated maximum distances for selecting the proper fiber optic cable lengths for each Weed module based on module wavelengths and typical fiber diameters.

Fiber Optic Module	2E07 / 2D07	2E10 / 2D10	2E09 / 2D09	2E36 / 2D36	2E46 / 2D46
Fiber Operating Wavelength	850nm	850nm	1300nm	1300nm	1300nm
Fiber Diameter	62.5/125µm	62.5/125µm	62.5/125µm	9/125µm	9/125µm
Fiber Type	Multimode	Multimode	Multimode	Single-Mode	Single-Mode
Typical Wavelength Attenuation	3.5dB/km	3.5dB/km	1.5dB/km	0.5dB/km	0.5dB/km
Optical Power Budget	12dB	17dB	12dB	10dB	16dB
Estimated Max. Distance (km)	3.429	4.857	8.000	20.000	20.000*
Estimated Max. Distance (mi)	2.130	3.017	4.970	12.427	12.427*

* The 2E46 is capable of much longer distances, but is constrained by the ControlNet maximum network limit.

Table 2-4

Estimated Cable Lengths

The maximum length of a fiber cable section for any Weed fiber optic module is dependent on the quality of the fiber, number of splices, and the number of connectors. The total attenuation for a cable section **must** be less than the stated optical power budget of the optical module selected. Estimated fiber optic cable distance is based on typical cable attenuation and assumes optimum cable quality.   See sections 'Understanding Fiber Limitations' and 'Understanding fiber Attenuation' for more information on this subject.

Maximizing System Cables

Whenever possible avoid splicing your cable. Connectors can cause considerable attenuation and limit the maximum length of your system. Be certain to measure the attenuation of each different cable sections after the cable is installed.

Layout of ControlNet Modules

The ControlNet modules have LED indicators for power and device communications. Below in figure 2-3, are the layouts for all optical and electrical modules:

1. Receive Optical Port (ST)
2. Transmit Optical Port (ST)
3. Receive Communication LED
4. Transmit Communication LED
5. Bi-Directional Electrical Port (BNC)
6. Power LED
7. Electrical Communication LED
8. Backplane Connector
9. Optical Diagnostic Connector (D-Series Only)
10. DIN Rail Spring-Clip
11. Ventilation Louvers
12. Cover Release Tab
13. Chassis Ground Tab
14. EOTec 2000 Series Model Number

Figure 2-3

ControlNet Stack LED Indicators

This section describes the functionality of the LEDs on each module within a ControlNet Stack. Each stack will have a power supply and at least one electrical interface module (2C20). A stack can contain additional Electrical Interface Modules (EIMs) or Optical Interface Modules (OIMs) can be added to provide noise immune communications over greater distances.

EOTec 2C20 Electrical Interface Module

LED	Function	Description
PWR	**Power**	Power ON – On solid **green** when power is applied. LED will turn off if the power supply fails.
COM	**Communication**	Communication Status – Blinking or solid **green** indicates active communication with a ControlNet device.

EOTec Optical Interface Modules

LED	Function	Description
RX	**Receive**	Receive Optical Activity Indicator: Solid **amber** or blinking with activity
TX	**Transmit**	Transmit Optical Activity Indicator: Solid **green** or blinking with activity

EOTec Power Supply Modules

LED	Function	Description
PWR	**Power**	Power ON – On solid **green** whenever the 7.5Vdc BUS operating power is available to the other modules in the stack.

Electrical and Fiber Connections

Weed ControlNet Stacks provide coax and fiber connections to devices on the factory floor through star, daisy-chain, or point-to-point topologies.

Electrical and Fiber Connection Guidelines

The EOTec ControlNet Stacks connect directly to your ControlNet device via the ControlNet trunk line (RG-6 coax cable). Devices can then be added along this Physical Media Layer. For short distances up to 1000 meters there may be no need for a ControlNet Stack, but as more nodes are added to the trunk line an EOTec electrical repeater may be the answer to extend the overall distance or connecting various segments along your trunk line. For more information on coax limitations, see Understanding Coax Limitations.

Where noise immunity is a concern or distances greater than 1000 meters are required fiber optic cable can be used to communicate between stacks to achieve your unique needs. For longer distance or environments where noise emissions are a concern an optical repeater can offer various options. Consult the optical specifications in tables 2-2a, 2-2b for more information on selecting the correct module for your application.
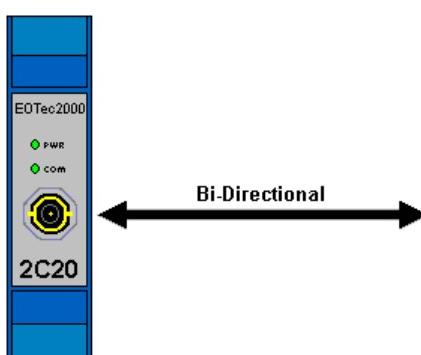
Electrical Interface Modules   **Optical Interface Modules**
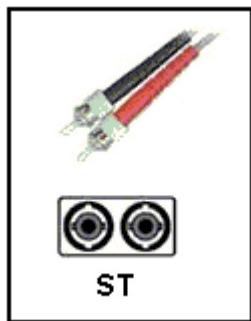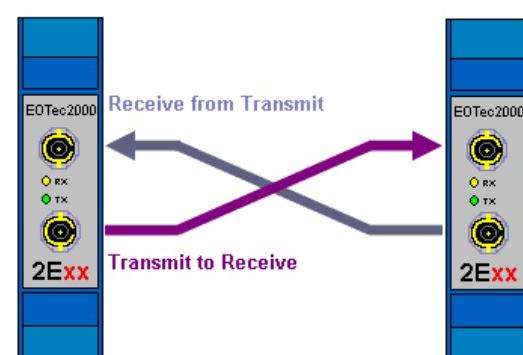
Each fiber optic module is comprised of a pair of ST connectors. For each fiber port there is a Transmit (TX) and Receive (RX) signal. When making your fiber optic connections, ensure that the Transmit port of the first module connects to the Receive port of the second module (TX to RX), and the Transmit port of the second module connects to the Receive port of the first module (RX from TX). Fiber optic cables with color-coded ST connectors are recommended to help ensure proper connection from Transmit to Receive ports.

3

Network Configuration

This chapter describes various network topologies you can configure using EOTec 2000 ControlNet Stacks and provides details on the Weed hardware to use.

Network Setup and Operation

As each network is different, Weed offers easily configured modules to meet your unique ControlNet needs. The EOTec 2000 ControlNet Stacks are modular to allow ease of selection in meeting these communication needs.

To begin selection, first start at the heart of the stack with the 2C20. This module has a bi-directional BNC port to connect directly to your ControlNet coax trunk line. Communication to other modules is made easy through the interconnection BUS on the back of each EOTec module. This module will be your BUS master and will control direction of communication of all other modules in this stack. See Device Jumpers and Module Address for more details on how to properly configure each ControlNet Stack.

Next, a power module must be selected. This can either be an AC or DC powered module depending on your specific needs. These modules receive various electrical inputs and convert to a low power DC voltage for use on the ControlNet Stack's interconnection BUS. For mission critical applications, a redundant power supply can be added and optional relay modules are also available where alarm applications are required. For selecting the correct power source for your application, consult EOTec Power and Alarm Connections.

Now it is time to determine communication type. For electrical communication a second 2C20 can be configured into a stack as an electrical repeater. This will extend the electrical trunk line up to an additional 1000 meters. For additional segments, additional repeaters must be deployed (see Understand Coax Limitations for proper planning and installation). This works well locally over short distances where noise immunity is not a concern.

However, for those users challenged by long distance communications or environments with high electrical noise, an optical repeater is the device of choice. Weed offers a variety of choices to meet your distance and wavelength requirements. For areas where glass fiber degradation is a concern or measuring light intensity a requirement, a diagnostic 'Series 2Dxx' module can be selected. This module performs the same functions and has the same optical specifications as the 'Series 2Exx' module, but additionally reports optical power levels. Refer to EOTec Optical Fiber Modules and EOTec Optical Diagnostic Modules to make your optical selections.

Device Jumpers

When configuring a ControlNet Stack, some of the communication modules (electrical and optical) will need to be reconfigured. By default all 2C20 modules will come configured as the 'Master' device (refer to Default Settings) so only one module of each ControlNet Stack can remain in this setting. As shown in table 3-1 select a unique address for all other modules within the stack (also see Stack Address). For the ControlNet protocol, optical modules do not function properly as a bus 'Master' so each stack must include a 2C20.

Additionally, optical modules have a protocol jumper that must be set to 'E' for use in the ControlNet environment and a power level jumper for selecting light intensity. In normal use this will be set to 'H' for high light intensity, but for very short optical links a low 'L' setting is provided to help in avoiding optical overdrive. See table 3-2 for all optical module jumper settings.

Power supplies have no jumper settings and come ready to use as ordered.

2C20 Electrical Module	
Bus Address	**Jumper Setting**
Bus Master	M
Address One	1
Address Two	2
Address Three	3
Address Four	4

Table 3-1

| All Optical Modules	
Bus Address	**Jumper Setting**
Bus Master	M
Address One	1
Address Two	2
Address Three	3
Address Four	4
Protocol	**Jumper Setting**
ControlNet	E
Power Level	**Jumper Setting**
High Intensity	H
Low Intensity	L

Table 3-2

Figure 3-1

17
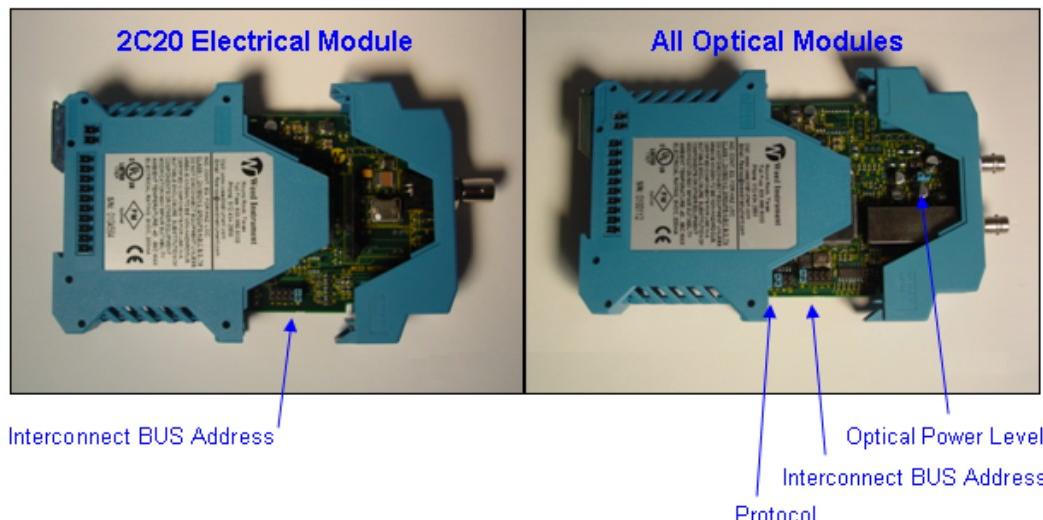
Stack Address

Each communications module on the Stack's interconnection BUS is required to have a unique address. Each stack must have one 'Master' and all other modules require separate addresses (1 through 4). As shown on the left of figure 3-2, each address has a bi-directional communication path across the backplane in each stack.
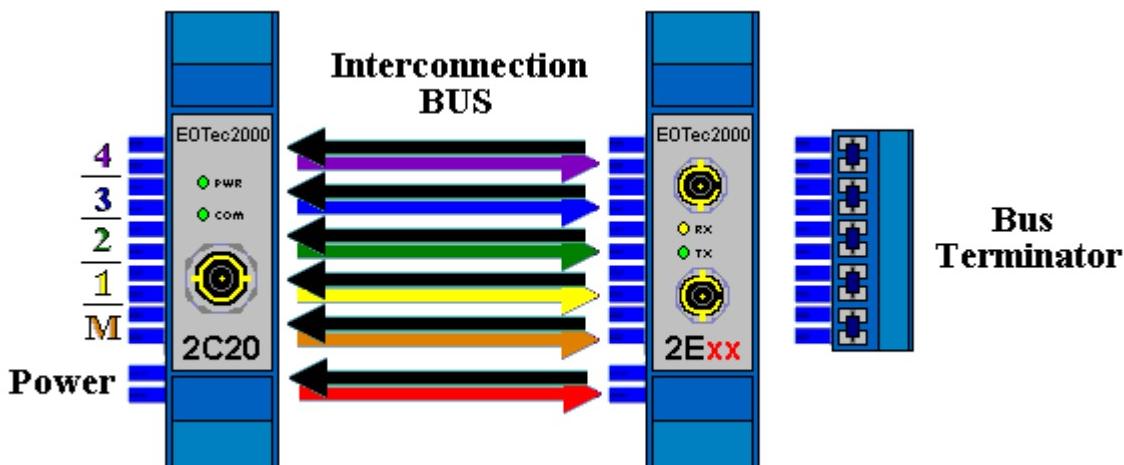
Figure 3-2

Stack Termination

To insure high quality signals across the ControlNet Stack's interconnection BUS, a terminator block will need to be added to the end of each stack. As shown in figure 3-2, the terminator has a connector that will plug into the right most module as you face your ControlNet stack. This eliminates any distortion that occurs on the data lines coming into the stack from both the electrical (BNC) and optical (ST) ports.

Stack'em as You Like

When the ControlNet modules are attached to create a ControlNet Stack, the modules can be placed in any order. Because each module in the stack has a unique bus address; they can be placed in any order and still communicate properly over the bus. For more examples of ControlNet Stacks refer to the EOTec 2000 ControlNet Stack Options. Also, review Point-to-Point, Daisy-chain, and Star Communication sections.

Supported Network Configurations

When connecting ControlNet coax segments together there are three topologies which are supported by EOTec 2000 ControlNet Stacks. The Point-to-Point connection uses electrical/optical repeaters that connect two ControlNet segments together or simply extends the communication length between two devices. The cascade or Daisy-Chain can be used to connect multiple ControlNet devices or multiple segments together, and the Star configuration allows several devices or segments in multiple directions to be connected through a centrally located hub (Star Stack). These three configurations can be made entirely of RG-6 coax cable or a combination of both coax and optical fiber.

Point-to-Point Communication

Point-to-Point communication is made between two ControlNet devices. An electrical connection can be up to 1000m. A ControlNet stack can be used as an electrical repeater (as shown in figure 3-3) to connect two trunk line segments together or to simply connect a single node (up to 1000m/repeater). An optical repeater (as shown in figure 3-4) can be used to extend communications over greater distances.
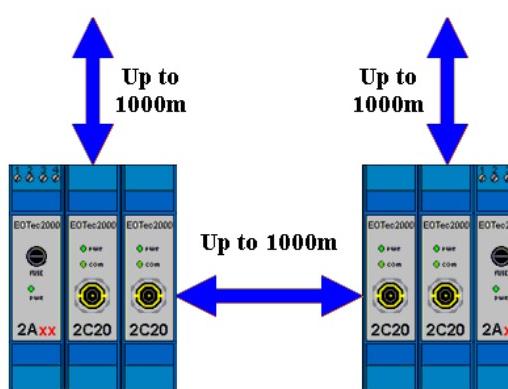
Electrical Repeater   **Optical Repeater**
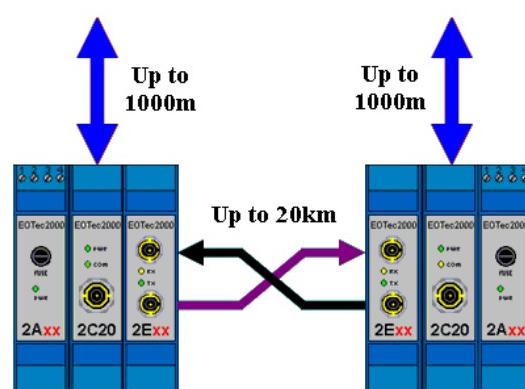
Figure 3-3   **Figure 3-4**

The configuration below in figure 3-5 can be confused with an optical repeater. However, this use of optical modules is not supported for the ControlNet protocol and will induce continual data errors. By choosing the proper optical modules to span the entire distance required (as shown in figure 3-4) this invalid configuration is avoided.

Invalid Optical Repeater
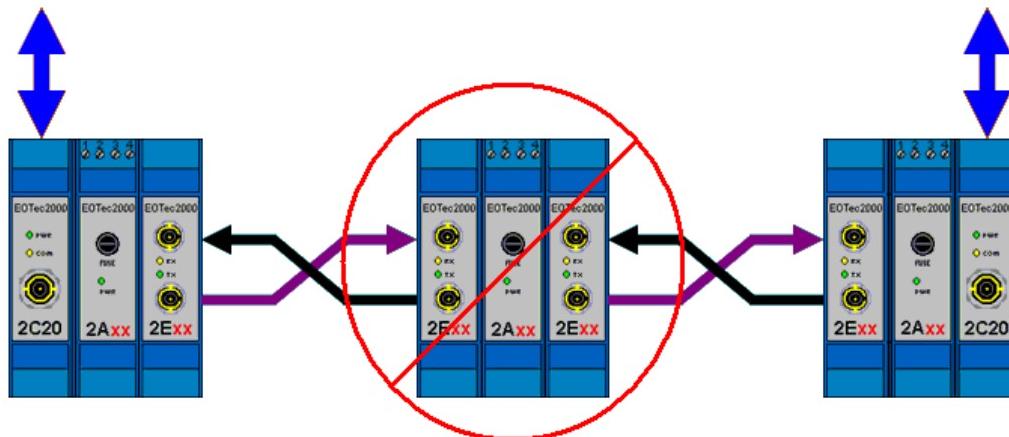
Figure 3-5

Bi-Directional Electrical Segment of ControlNet Trunk Line
Bi-Directional Optical Extention of ControlNet Trunk Line

Daisy-Chain Communication

A Daisy-Chain (also known as Cascading) is used to connect multiple nodes to one network segment. This term is also used when interconnecting several segments via electrical repeaters to form a network of continuous segments (see figure 3-6).
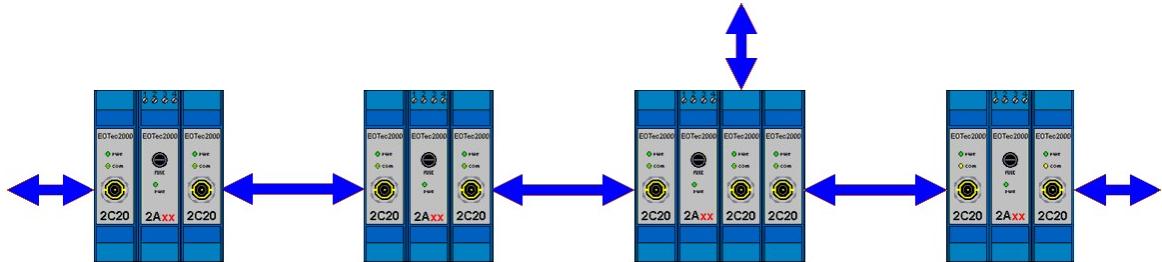
Figure 3-6

By using optical repeaters, several ControlNet coax segments can be interconnected together over long distances (see figure 3-7). Or an optical segment can be used to interconnect multiple coax segments to form one network (see figure 3-8). Any combination of repeaters can be used and is limited only by the ControlNet maximum delay time.
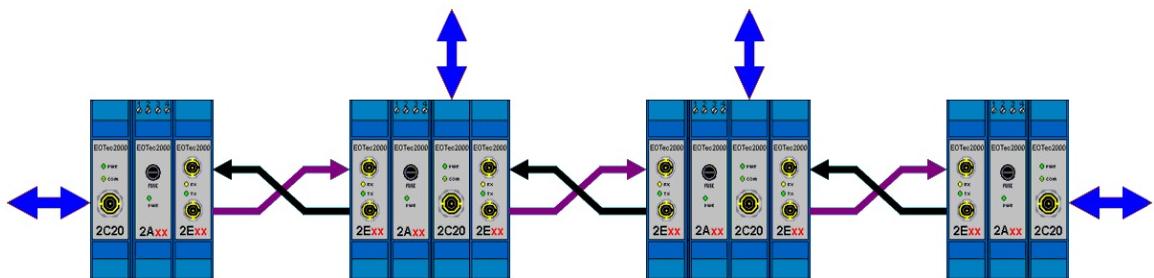
Figure 3-7
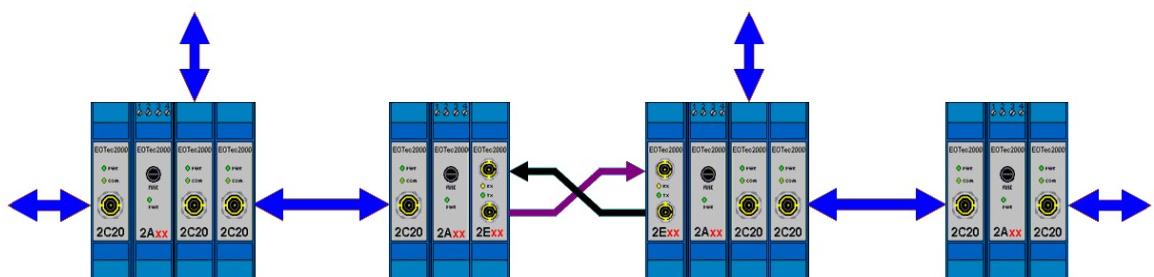
Figure 3-8

Bi-Directional Electrical Segment of ControlNet Trunk Line
Bi-Directional Optical Extention of ControlNet Trunk Line

Star Communication

A Star configuration can be used to connect several ControlNet nodes into one network, but in this configuration there is a centrally located hub (Star hub) that connects all other nodes in the network. A star configuration can be used alone or it can be used in combination with other configurations including additional stars (see figure 3-9). A ControlNet Stack configured as a repeater will have two communication points, but a star stack can have 3 to 5 points of communication. Refer to table 3-3 for more information on the ControlNet Stacks in the configuration below.
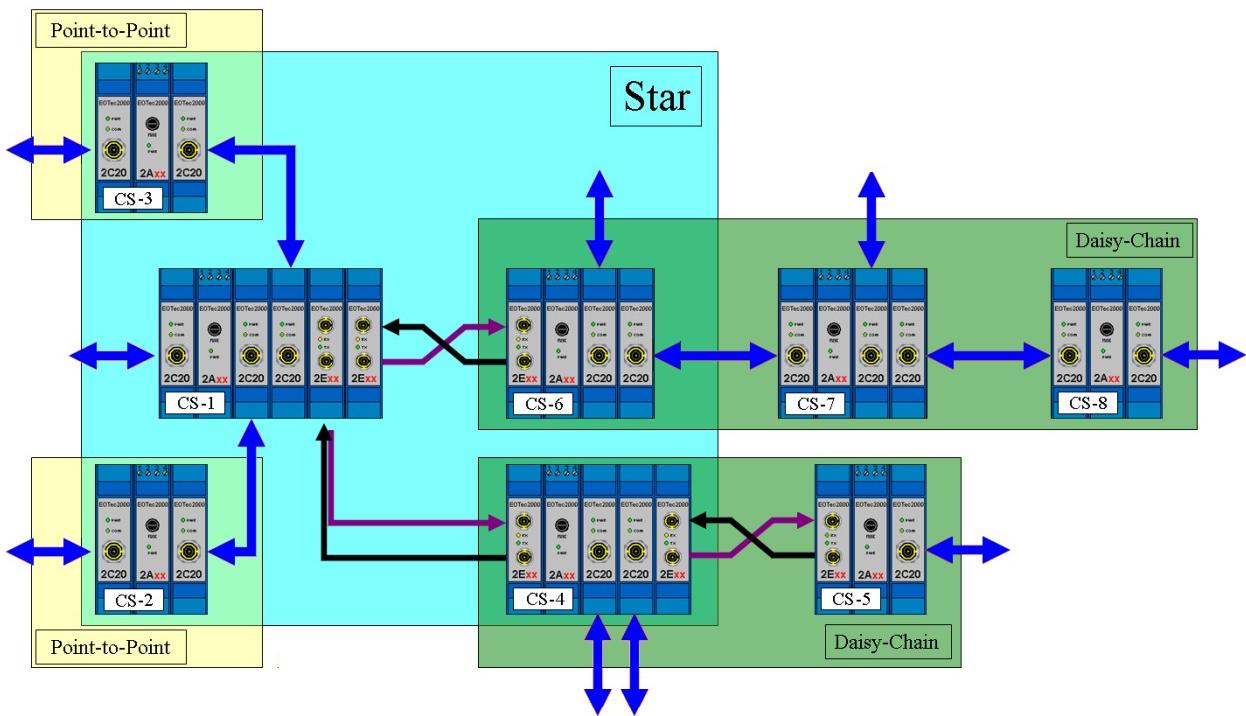
Figure 3-9

ControlNet Stack	Stack Description	Communication Points
CS-1	Star Hub – Center of network	5
CS-2	Electrical Repeater	2
CS-3	Electrical Repeater	2
CS-4	Optical to Optical Star Repeater	4
CS-5	Optical to Electrical Repeater	2
CS-6	Optical to Electrical Star Repeater	3
CS-7	Electrical Star Repeater	3
CS-8	Electrical Repeater	2

Table 3-3

Bi-Directional Electrical Segment of ControlNet Trunk Line
Bi-Directional Optical Extention of ControlNet Trunk Line

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Network Configuration Tips

The following applications tips are provided to help plan and install ControlNet networks.

- Plan the network wiring to minimize the number of connections and the length of the network cables. Simple and short is always better. When planning your network using Weed Instrument ControlNet Stacks, refer to the Planning a Network section of this manual.

- While ControlNet supports up to 99 nodes, ControlNet has a limitation of 48 nodes per coax segment. Coax can communicate up to 1000 meters, but for each tap added 16.3 meters must be subtracted from this overall segment length. See Understanding Coax Limitations for more details.

- Another limitation is the propagation delay for the entire network (121μs) this amounts to approximately 20 kilometers of optical fiber for the entire network. Understanding this protocol limitation will help you to design your network wisely. See Understanding Propagation Delay for more details.

- While your ControlNet nodes can be connected in one continuous string of repeaters, the maximum ControlNet delay time for the entire network (121μs) may prevent the use of a long string of network repeaters (daisy-chain). However, the Star configuration may help to overcome this by strategically placing a centrally located 'hub' and connecting directly from the center of your network to the various other locations.

- In a Star configuration, it is important to connect the **lowest** ControlNet address or moderator directly to the Star-Hub in the center of your network (shown as device CS-1 in figure 3-9).   This allows module diagnostic LEDs to function best.

- A dual channel configuration increases network reliability by providing an alternative path for message flow in the event of a network segment failure. When a communication segment break occurs, messages are automatically captured from the alternative communication path.

- Using redundant power supplies will insure that critical communication links stay operational.

- Power supply relays provide monitoring from a central location to easily warn users immediately of any power failures.

- Employing optical diagnostic ports to monitor optical power levels (light intensity) will warn users remotely of any broken or degrading glass fiber connections.

4
Planning and Installation

This section discusses the limitations of ControlNet and explains how to plan and install your network, and provide advice and application tips to avoid common pitfalls.

Planning a Network

The ControlNet Stack system gives you the flexibility to design a communication network for your particular application. To take full advantage of this flexibility, you should spend sufficient time planning how to install your network **before** assembling any of the hardware.

Create a project plan and checklists to help you determine the components needed for your application.

- Determine how many nodes (taps) will be in the coax segment
- Determine the length of the fiber segments
- Decide the type of fiber cable and connections to use
- Determine how many fiber connectors you will need
- Calculate the maximum allowable segment length
- Determine whether you will need additional repeaters and coax segments

Understanding EOTec/ControlNet Terminology

It is important when planning and installing a ControlNet network to understand the proper terminology used. Below in tables 4-1a, 4-1b is a list of commonly used terms.

| Term	Description
BNC Connector	Type of connectors used for coax electrical connections. Used on all EOTec 2C20 modules.
ControlNet Stack	A communication device constructed of EOTec 2000 series modules. This consists of at least 1 power supply module and 2 communications modules (2 electrical or 1 electrical and 1 optical).
Coax Segment	Trunk-cable sections connecting nodes via taps with a terminator at each end and includes no repeaters.
Electrical Interface Module (EIM)	An Electrical Interface Module is used to connect coax network segments together (2C20).
Electrical Repeater	An active physical layer component that reconstructs and retransmits all traffic bi-directionally from one coax segment to another coax segment. Requires a minimum of two 2C20s.
Fiber Segment	A length of fiber optic cable connecting two optical modules or two coax segments.

Table 4-1a

Term	Description
Interconnection BUS	The backplane bus that connects all EOTec 2000 series modules into a ControlNet Stack.
Link	A link is another word for segment.
Module	A modular package that is connected together via the Interconnection BUS to construct a ControlNet Stack.
Network	A network is the collection of nodes connected together by segments (coax or fiber).
Node	Any physical device connecting to the ControlNet media system which requires a network address in order to function on the network. A network may contain a maximum of 99 nodes. This node address must be in the range of 1 - 99 and be unique to that network.
Optical Converter	A ControlNet Stack that combines both an electrical and optical module. Converts electrical signals to light pulses to be transmitted over great distances or through hazardous areas.
Optical Interface Module (OIM)	A fiber Optic Interface Module is used to anchor both ends of a fiber segment. Used to join coax segments (2Exx; 2Dxx).
Optical Repeater	An active physical layer component that retransmits bi-directionally from one segment to another.
Power Supply Module	A module used to power EOTec 2000 ControlNet Stacks (2Axx).
Power Supply Relay	Optional relay output used to provide a loss of power signal to a remote location.
Redundant Power Supply	An optional second power supply module used to ensure insure EOTec stacks are always powered.
Repeater	Used to increase the number of nodes, extend the total length of your network, or create a star configuration. A repeater can extend either an electrical or optical segment. When you insert a repeater into your cable system, you create a new segment.
Segment	A segment consists of either coax or fiber cable.
ST* Connector	Type of connectors used for optical connections. Used on all EOTec "2Dxx" and "2Exx" series optical modules. *ST is a registered trademark of AT&T
Tap	The coax connection between any device and the ControlNet media system. Contains an electrical circuit and must be used to connect all ControlNet devices to the coax trunk line.
Terminator (coax)	A 75Ω terminator must be installed on the 2 taps at each end of every coax segment.
Terminator Block (ControlNet Stack)	To insure high quality signals across on the ControlNet Stack's interconnection BUS, its recommended to add a terminator block at the end of each stack.
Trunk Cable	The trunk cable is the bus, or central part of the ControlNet Coax media system. The trunk cable can be composed of multiple sections of cable. The standard cable used to construct trunk-cable sections is quad shield RG-6 type Coax.

Table 4-1b

Understanding Coax Limitations

The total allowable length of a segment containing standard RG-6 quad shield cable depends upon the number of taps in your segment. There is no minimum trunk-cable section length requirement. The maximum allowable total length of a segment is 1,000 meters with two taps connected. Each additional tap decreases the maximum length of the segment by 16.3m. The maximum number of taps allowed on a segment is 48 with a maximum segment length of 250m as shown in figure 4-1.

Maximum Allowable Segment Length
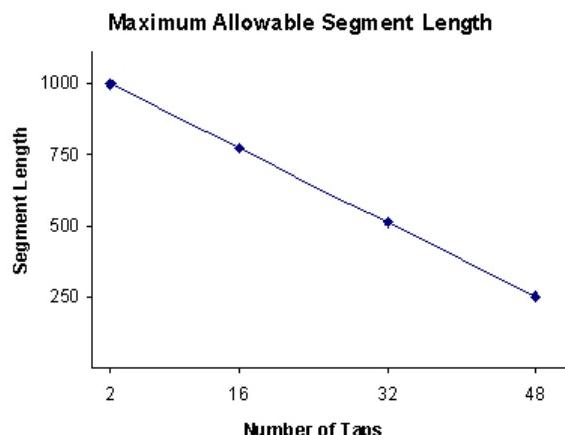
Example: If your segment requires 16 taps, the length for each segment is:

$$1000m - [16.3m \times (16 - 2)]$$
$$1000m - (16.3m \times 14)$$
$$1000m - 228.2m = 771.8m$$

Figure 4-1

Understanding When to Use Repeaters

You need to install repeaters if your system requires more than 48 taps per segment, or a longer trunk cable than the specification allows (see Understand Coax Limitations).

ControlNet allows for a maximum of 99 addressable nodes. Repeaters do not require an address so they do not count against the total of 99. As many as 48 tap connections are allowed on a maximum segment length of 250m (all coax cable must total to less than 250m). An electrical repeater can be used locally (distances up to 1000m) or for longer distances an optical repeater can be installed.

Understanding the Benefits of Fiber

Fiber has benefits over electrical coax cable. Table 4-2 lists many of these benefits

Feature	Benefit
No Ground Potential	Fiber carries no electrical current so it is completely isolated from any potential electrical sources that cause disruptions on copper media and provides immunity to lightning strikes.
No EMI	Fiber is made of glass so it is immune to EMI (ElectroMagnetic Interference). Use Fiber in noisy environments such as heavy machinery and multiple cable systems where copper could suffer communication disruptions. Fiber is also a great choice for high-voltage environments.
No Sparks	Fiber conducts light not electrical pulses so it is a safe choice for carrying data communication through hazardous areas.
Less Signal Loss	Fiber media carries data using light pulses not electrical current. Thus fiber can carry data much greater distances. Greater distance between repeaters means that fewer repeaters are needed between long distance nodes.
Less Size and Weight	Fiber cables are much smaller and lighter than coax cables.

Table 4-2

Understanding Fiber Limitations

While fiber has many benefits over coax there are limitations too. Every network that uses fiber repeaters must maintain a minimum signal level for each fiber segment in order to achieve effective signal strength. Attenuation of a fiber segment is effected by the quality of the termination at each connector, splices, bulkheads and the fiber cable itself. At any time, the total amount of attenuation shall not exceed the power budget of the optical repeater module used.

Understanding EOTec Fiber Modules

When choosing an optical module to use in your configuration, a commonly asked question is "What particular cable type is used with a particular module?" You must select a module (and the corresponding cable type) based on the distance you want the data to travel. There are two types of fiber cable: single and multi-mode. These two cable types differ in that single mode cable allows light to travel in a single path. Multi-mode cable allows light to travel in multiple paths. Single-mode cable is generally used in longer-distance applications.

The maximum length of a fiber cable section for the fiber optic modules is dependent on the quality of the fiber, number of splices, and the number of connectors. When estimating maximum cable length, take into account attenuation that occurs along the entire fiber path. Attenuation refers to the decay of the strength of the light signal along the cable path. Consult your local distributor for attenuation specifications prior to purchasing your fiber media components.

Table 4-3 below provides specifications for selecting the proper Weed fiber optic module for your application:

Fiber Optic Module	2E07 / 2D07	2E10 / 2D10	2E09 / 2D09	2E36 / 2D36	2E46 / 2D46
Fiber Operating Wavelength	850nm	850nm	1300nm	1300nm	1300nm
Fiber Diameter	62.5/125µm	62.5/125µm	62.5/125µm	9/125µm	9/125µm
Fiber Type	Multimode	Multimode	Multimode	Single-Mode	Single-Mode
Typical Wavelength Attenuation	3.5dB/km	3.5dB/km	1.5dB/km	0.5dB/km	0.5dB/km
Optical Power Budget	12dB	17dB	12dB	10dB	16dB
Estimated Max. Distance (km)	**3.429**	**4.857**	**8.000**	**20.000**	**20.000***
Estimated Max. Distance (mi)	**2.130**	**3.017**	**4.970**	**12.427**	**12.427***

* The 2E46 is capable of much longer distances, but is constrained by the ControlNet maximum network limit.

Table 4-3

Understanding Fiber Attenuation

You must calculate the power budget for your fiber cable. Once you start modifying the lengths of the cable, installing bulkhead or fusion splices, installing longer distances, exposing the cable to multiple sharp bends, or employing different quality cable and connector types, you must determine your attenuation levels. Use the example below to help you determine fiber attenuation levels.

From table 4-3 above, you can see the power budget for a 2E07 Optical Module is 12dB. This means that the maximum amount of attenuation between this module and the one connected at the other end of the fiber can not exceed 12dB. This power budget is valid throughout the operating temperature range (-40º to +85º C). If you modify the cables with splices then you must recalculate the attenuation levels.

Use the steps in table 4-4 to determine the correct fiber attenuation for selecting the correct EOTec optical modules for your application.

Step	Description	Explanation
1	Determine total power budget	Given the application, the size of the network, and fiber type, how much total loss (dB) is expected and allowed?
2	Determine insertion loss – Add up the loss from connectors, splices, bulkhead, etc.	Account for all added attenuation from insertion loss on the fiber segments. Do not include the two connectors on the ends of each fiber cable.
3	Determine cable loss – Add up the loss from all cable lengths.	Select fiber cable and identify typical power loss. Loss = loss of light over 1 kilometer (dB/km)
4	Compare and select	Total loss of light cannot be greater than the power budget of the selected optical module.

Table 4-4

If the total power loss (sum of Steps 2 & 3) is less than the power budget of the selected optical module (Step 1), then you are within the power budget. If however, the power loss (sum of Steps 2 & 3) is less than the power budget, then you will need to reconfigure the topology, shorten cable lengths, or select a different optical module.

> **Example:** This example is for a multi-mode fiber connection going through a bulkhead and one spliced fiber optic cable to a mating fiber connection 3 kilometers away.

- Optical module power budget from Table 4-3
  - 2E07 = 12dB @850nm (62.5/125μm)
  - 2E10 = 17dB @850nm (62.5/125μm)
  - 2E09 = 12dB @1300nm (62.5/125μm)
- Fiber cable having an attenuation of 3.5dB/km @ 850 nm; 1.5dB/km @ 1300nm
- For insertion loss, subtract a minimum attenuation of 1dB for each added connector, splice, patch panel, bulkhead, etc. (not to include the terminating connectors on each end of fiber).

Insertion Loss (dB)
The attenuation lost from connectors, splices, patch panel, bulkhead, etc.

$$\text{Insertion Loss} = (1 \text{ bulkhead} + 1 \text{ splice}) \times (\text{minimum connector attenuation})$$
$$= 2 \times 1\text{dB}$$
$$= 2\text{dB}$$

Cable Loss (dB)
The attenuation lost from the cable length required to connect the link.

$$\text{Cable Loss @ 850nm} = 3 \text{ kilometers} \times 3.5\text{dB} \text{ (typical attenuation for 62.5/125μm @ 850nm)}$$
$$= 10.5\text{dB}$$
$$\text{Cable Loss @ 1300nm} = 3 \text{ kilometers} \times 1.5\text{dB} \text{ (typical attenuation for 62.5/125μm @ 1300nm)}$$
$$= 4.5\text{dB}$$

Total Attenuation (dB)
The total attenuation lost from both inserted devices and cable length.

$$\text{Total attenuation} = (\text{cable loss}) + (\text{insertion loss})$$
$$\text{Total Loss @ 850nm} = 10.5\text{dB} + 2.0\text{dB}$$
$$= 12.5\text{dB @ 850nm} \text{ (required power budget)}$$
$$\text{Total Loss @ 1300nm} = 4.5\text{dB} + 2.0\text{dB}$$
$$= 6.5\text{dB @ 1300nm} \text{ (required power budget)}$$

The total attenuation accumulated over this 3 kilometer segment is 12.5dB so the 2E07 model is under budget for this application and should not be used. However, this application is well within the budget of the 2E10 model so it is good choice to use in this application. Also, if 1300nm is preferred then the 2E09 is the choice to make.

Understanding Propagation Delay

The ControlNet Maximum Propagation Delay specification refers to the worst case signal delay between any two nodes on a network. You will need to figure out the worst case scenario based on media distances and the number of EOTec modules which the data signals will pass through.   You should be aware that this does not mean all media and EOTec modules in your network; only the media and modules that link the two furthest nodes of your system.

Network delays include the delays through coax and fiber media, coax electrical modules (2C20), and optical modules (2Exx, 2Dxx).   Use Example 1 and Example 2 to help you understand   which media and Weed modules to use when calculating maximum propagation delay.

In order for a network to operate, the sum of the network's delays must be equal to or less than the ControlNet specified **maximum propagation delay of 121μs**. The total network allowable delay each way is 121μs. The propagation delays through taps are minimal and can be ignored.

Listed in table 4-5 are delay values for EOTec ControlNet devices and media:

Media Item	Propagation Delay Time
2C20	800ns
2E07 / 2D07	100ns
2E09 / 2D09	100ns
2E10 / 2D10	100ns
2E36 / 2D36	100ns
2E46 / 2D46	100ns
RG-6 Coax Cable	4.17ns/meter
Multi-mode Fiber	5.01ns/meter
Single Mode Fiber	5.01ns/meter

Table 4-5

Example 1: Maximum Delay (Single Channel)

The following example (figure 4-2) shows a star network designed with both coax and optical fiber segments. Each delay in the network is marked D1 through D9. Additionally, the network is divided at the star hub into 3 separate links (♣, ♦, ♠) to help examine the various delays within each link (see table 4-6). It is important to note that maximum delay time is based on the maximum number of repeaters in series and maximum length of the media used between the two nodes that are furthest apart in the system.
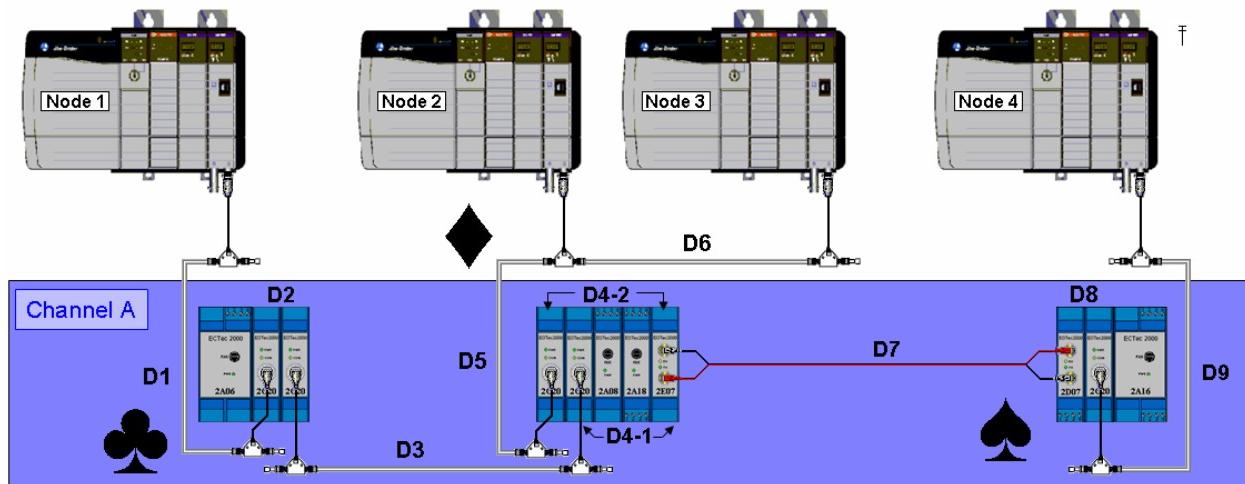
Figure 4-2

With Node 1 in a parallel segment (♣ Link) to the segment where Nodes 2 and 3 reside (♦ Link), worst case delay is calculated using only the longer of these two segments. The path through the ♣ Link (table 4-6) is longer than the path through the ♦ Link (table 4-7); therefore delays D4-2, D5 and D6 are not needed in this calculation. The worst case delay is only calculated by adding up the delays in ♣ Link (table 4-6) and ♠ Link (table 4-8) these are the delays between the furthest two nodes in this system (Nodes 1 and 4) See tables 4-9a and 4-9b for total propagation delay details.

---

† While Nodes 1 through 4 are shown using a *ControlLogix™ 1756 chassis, they are interchangeable with any ControlNet controller using BNC connectors.

* ControlLogix is a registered trademark of Rockwell Automation

♣ Link		
Delay	**Description**	**Total (µs)**
D1	300m (coax) x 4.17ns =	1.2510
D2	2 (2C20s) x 800ns =	1.6000
D3	850m (coax) x 4.17ns =	3.5445
D4-1	[1(2C20) x 800ns] + [1(2E07) x 100ns] =	.9000
Total Channel A Propagation Delay		**7.2955**

Table 4-6

♦ Link		
Delay	**Description**	**Total (µs)**
D4-2	[1(2D07) x 100ns] + [1(2C20) x 800ns] =	.9000
D5	15m (coax) x 4.17ns =	.0626
D6	250m (coax) x 4.17ns =	1.0425
Total Channel B Propagation Delay		**2.0051**

Table 4-7

♠ Link		
Delay	**Description**	**Total (µs)**
D7	2640m (fiber) x 5.01ns =	13.2264
D8	[1(2D07) x 100ns] + [1(2C20) x 800ns] =	.9000
D9	20m (coax) x 4.17ns =	.0834
Total Channel A Propagation Delay		**14.2098**

Table 4-8

The worst-case propagation delay of 21.5053µs shown in tables 4-9a and 4-9b below is acceptable because it is well within the maximum allowable network delay time of 121µs. Also, notice that electrical repeaters have been used to connect ♣ Link (table 4-6) to ♦ Link in this system as the total segment lengths between nodes 1, 2, and 3 is beyond the limitations of coax cable. The Star hub has been installed to add a fiber segment to attach to Node 4 a couple kilometers away.

♣ Link + ♠ Link		
Delay	**Description**	**Total (µs)**
D1	300m (coax) x 4.17ns =	1.2510
D2	2 (2C20s) x 800ns =	1.6000
D3	850m (coax) x 4.17ns =	3.5445
D4-1	[1 (2C20) x 800ns] + [1 (2E07) x 100ns] =	.9000
D7	2640m (fiber) x 5.01ns =	13.2264
D8	[1 (2D07) x 100ns] + [1 (2C20) x 800ns] =	.9000
D9	20m (coax) x 4.17ns =	.0834
Total Network Propagation Delay		**21.5053**

Table 4-9a

Example 2: Maximum Delay (Dual Channel)

This example begins where the previous example left off with the same single communication channel used in Example 1. However, now we will use a redundant communication path (channel B) to insure greater reliability for this ControlNet system. The cables for channel B must be routed in a different pathway from Channel A to insure this reliability. It is difficult to route two separate paths of equal length so it is important that the skew in the propagation delay of Channel A to channel B is no more than the ControlNet specified difference of 1.6µs between these two channels.
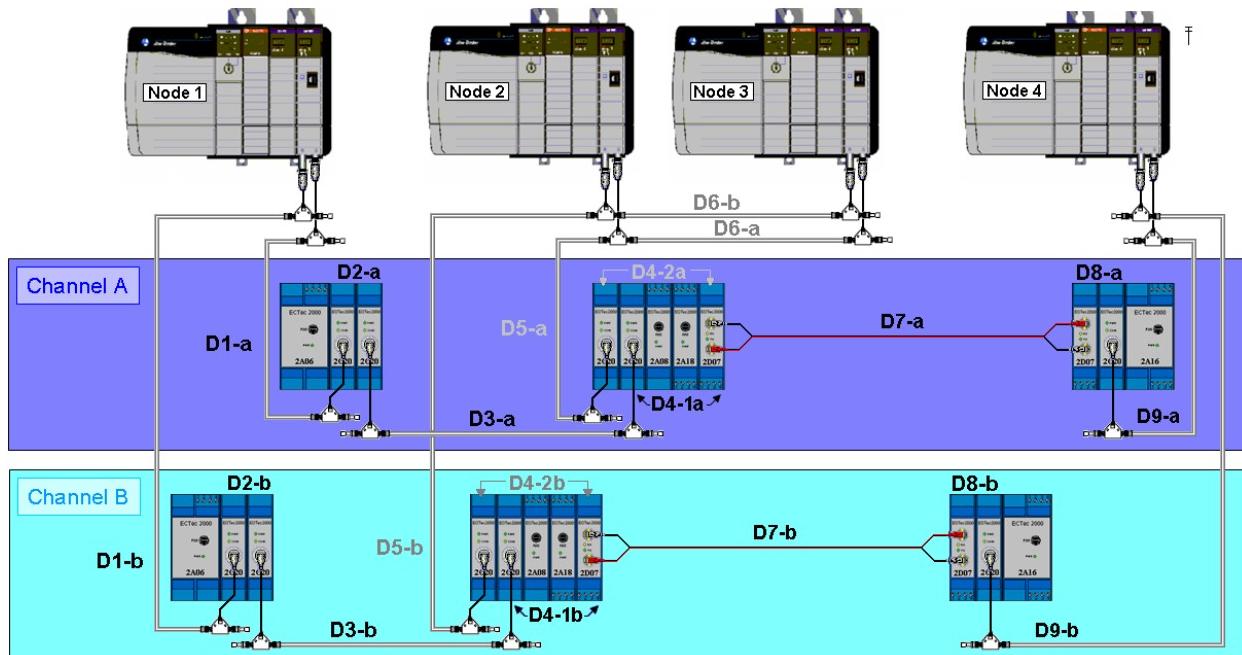
Figure 4-3

Delay	Description	Total (µs)
D1-a	300m (coax) x 4.17ns =	1.2510
D2-a	2 (2C20s) x 800ns =	1.6000
D3-a	850m (coax) x 4.17ns =	3.5445
D4-1a	[1(2C20) x 800ns] + [1(2E07) x 900ns] =	.9000
D7-a	2640m (fiber) x 5.01ns =	13.2264
D8-a	[1(2D07) x 100ns] + [1(2C20) x 800ns] =	.9000
D9-a	20m (coax) x 4.17ns =	.0834
Total Channel A Propagation Delay		**21.5053**

Table 4-9b

Delay	Description	Total (µs)
D1-b	320m (coax) x 4.17ns =	1.3344
D2-b	2 (2C20s) x 800ns =	1.6000
D3-b	860m (coax) x 4.17ns =	3.5862
D4-1b	[1(2C20) x 800ns] + [1(2E07) x 900ns] =	.9000
D7-b	2680m (fiber) x 5.01ns =	13.4268
D8-b	[1(2D07) x 100ns] + [1(2C20) x 800ns] =	.9000
D9-b	22m (coax) x 4.17ns =	.0917
Total Channel B Propagation Delay		**21.8391**

Table 4-10

A to B channel skew = 21.8391µs (ChB) – 21.5053µs (ChA) = 333.8ns

This example shows a valid redundant network as the calculated skew between channel A and B is only 333.8ns; well below the maximum network skew of 1.6µs. Also, note that channel B is now the longest distance between the furthest two nodes in this system and that 21.8391µs is now the maximum delay time.

Verifying Network Parameters

You can use *RSNetworx™ for ControlNet to determine whether or not your system meets the network parameter requirements. Based on your system planned requirements (NUT, SMAX, UMAX, types and length of cable, number and types of repeaters and worst case network delay); RSNetworx will validate the network configuration parameters. Once the parameters are validated, the software will tell you if your configured network is acceptable. If your network is not valid, you must adjust your planned requirements.

It is important to understand the application needs of the equipment within your network before adjusting network parameters as these adjustments can keep devices from communicating within an appropriate time frame. SMAX (maximum scheduled address) and UMAX (maximum unscheduled address) will be used by RSNetworx to determine the maximum addressable nodes that can communicate on the network. The NUT (Network Update Time) determines the interval time for each node to communicate.

Upon entering RSNetworx, from the toolbar menu, select Networks and then Properties. Enter your network parameters based on the application needs of your ControlNet system. Next select Media Configuration, the information entered here will be used to determine the maximum network propagation delay in your network. Enter the total amount of coax (RG-6 Coax Cable), and fiber (Glass Fiber Cable) used to connect the furthest two nodes in your system. This will be expressed in meters and round up to the nearest 100m. See Understanding Propagation Delay for further information on which media segments to include.

Next, you must enter the types of devices used to communicate on the ControlNet Physical Media Layer. You will notice that no Weed modules will be listed so the next best option will be to use equipment listed that has similar delay times. You can select the appropriate device from table 4-11 below that matches the appropriate Weed device in table 4-12. Enter the number of devices used to connect the furthest two nodes in your system. See Understanding Propagation Delay for further information on which EOTec modules to include.

Rockwell Automation		Weed Instrument	
Device	**Delay Time**	**Device**	**Delay Time**
1786-RPA	901ns	2C20	800ns
1786-RPFRL	100ns	2Exx/2Dxx	100ns

Table 4-11   **Table 4-12**

*RSNetworx is a registered trademark of Rockwell Automation.

Installing a Network

Weed Instrument sells the necessary equipment to install a communication connection on the physical media layer, but we do not offer installation services. Many customers retain qualified professionals to plan, install, and maintain their ControlNet systems. If your company does not retain such a staff we recommend you contract an installation specialist. The specialist you choose should install your cable and terminate it following the supplier's installation instructions.

However, a specialist is not necessary to connect your Weed ControlNet Stacks. Someone with installation experience can connect this equipment using the pre-installed cables.

Whether you are installing or maintaining a ControlNet system keep the following application tips in mind.

Coax Application Tips

The following applications tips are provided to help understand coax electrical networks.

- Taps contain passive electronics and must be used for the network to function properly. Other methods of connecting to a Coax trunk cable will result in reflected energy that will disrupt communications.

- A 75Ω terminator must be installed on the tap at each end of a segment.

- You should always calculate the three-dimensional routing path distance when determining cable lengths. Consider vertical dimensions as well as horizontal dimensions.

- When you install repeaters in series, use your ControlNet Network management Software (RSNetWorx) to verify that the system is an allowable configuration.

- Do not let any metallic surfaces on the BNC connectors, plugs, or optional accessories touch grounded metallic surfaces. This contact could cause noise on the network

- A disconnected drop cable can cause noise on the network. Because of this, it is recommend having only one unconnected drop cable per segment for maintenance purposes. Be sure to keep the dust cap on any unconnected drop cable.

Fiber Application Tips

The following applications tips are provided to help understand fiber optic networks:

- Avoid lengthening your cable by joining sections with connectors. Connectors can cause considerable attenuation and limit the maximum length of your system. Be sure to measure the attenuation of different cable sections after the cable is installed.
- It is recommended that all fiber segments be specified, installed, verified, and certified by a fiber optic specialist.
- Use high-quality connectors and fiber cable to stretch your power budget. Higher-quality connectors and cable can withstand a broader range of temperatures and distances.

Redundant Network Tips

With redundant media, nodes send signals on two separate segments. You can run a second trunk cable between your ControlNet nodes for redundant media. The receiving node compares the quality of the two signals and accepts the better signal to permit use of the best signal. This also provides a backup cable should one cable fail

Observe these guidelines when planning a redundant media system:

- Route the two trunk cables (trunk cable A and trunk cable B) differently to reduce the chance of both cables being damaged at the same time.
- Each node on a redundant-cable link must support redundant Coax connections and be connected to both trunk cables at all times. Any nodes connected to only one side of a redundant-cable link will result in media errors on the unconnected trunk cable.
- Install the cable systems so that the trunk cables at any physical device location can be easily identified and labeled with the appropriate icon or letter. Each redundant ControlNet device is labeled so you can connect it to the corresponding trunk cable.
- Both trunk cables (trunk cable A and trunk cable B) of a redundant-cable link must have identical configurations. Each segment must contain the same number of taps, nodes and repeaters. Connect nodes and repeaters in the same relative sequence on both trunk cables.
- Install cable on each side of a redundant system so that each cable is about the same length. The total difference in length between the two trunk cables of a redundant-cable link goes down as the number of repeaters increases.
- The total delay time between the two truck cables can not be skewed by more than 1.6µs.

5

Troubleshooting

Weed provides several solutions to help you diagnose trouble that may occur on the ControlNet Physical Media Layer. Understanding the information in this section will help to find the root cause of the problem and resolve it quickly.

Diagnosing Failure

Each EOTec 2000 ControlNet modules have LED indicators to help you diagnose a communication failure when trouble occurs. Understanding the indicators will help you identify the problem locally at the ControlNet Stack.

Also, Weed provides other optional features to help diagnose failures from a remote location such as power supply relay contacts to alert you to any lost power and 4 to 20mA connections to measure optical power levels real-time.
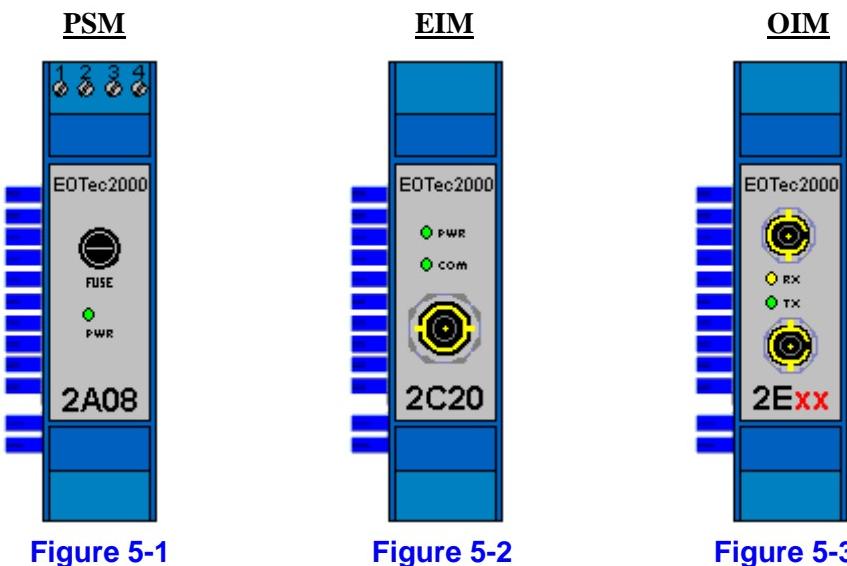
| **PSM** | **EIM** | **OIM** |
| Figure 5-1 | Figure 5-2 | Figure 5-3 |

The modules above are the 3 basic modules used in a ControlNet Stack. There is only one type of Electrical Interface Module (EIM) for ControlNet while there are four varieties of Power Supply Modules (PSM) and 6 varieties of Optical Interface Modules (OIM). However, the LED indicators for each type of module remain constant across the assorted varieties.

Take care when connecting a ControlNet Stack that each module has a unique address and the protocol is set properly. The LEDs on these modules indicate that data is moving through a port and not that it is being routed correctly.   Only the address and protocol jumpers insure data routes correctly through the ControlNet Stack.

The following troubleshooting suggestions have been provided to assist you should you have trouble with your EOTec 2000 ControlNet Modules.

Interrupting LED Indicators

Power Supply Module (PSM)		
Function	**Indication**	**Action**
Power (PWR)	Solid Green	Power is good.
	Off	Power is not being supplied to <u>Interconnection BUS</u>. 1. Check AC/DC input at cage clamp connector. 2. Check fuse. Replace if blown. 3. If both input power and the fuse are good, replace PSM.

For <u>PSM</u> illustration refer to figure 5-1 above.

Electrical Interface Module (EIM)		
Function	**Indication**	**Action**
Power (PWR)	Solid Green	Power is good.
	Off	Power is not being supplied to <u>Interconnection BUS</u>. 1. Check PWR light on PSM. 2. Insure all modules are connected correctly. 3. Check power input on Interconnection BUS. 4. If power is properly being supplied from the PSM, replace EIM.
Communication (COM)	Solid Green	Coax communication is being input to EIM. The LED flashes on for every packet. At the ControlNet data rate, the light will appear to be on continuously.
	Off	No input communication from coax on BNC. 1. Check BNC connector and check the other end of the coax to insure it is connected to another device. 2. Insure this stack has one EIM set to 'Master'. 3. If power and connections are both good, replace the EIM.

For <u>EIM</u> illustration refer to figure 5-2 above.

| Optical Interface Module (OIM)		
Function	**Indication**	**Action**
Receive (RX)	Solid Amber	Module is receiving data. The LED flashes on for every packet. At the ControlNet data rate, the light will appear to be on continuously.
	Off	No Transmit device connected. 1. Check the other end of this fiber to insure it is connected to a TX port. 2. Check to insure that TX port is transmitting (solid green TX light). 3. Check fiber for breaks. 4. If transmit is good and fiber is good, replace this module.
Transmit (TX)	Solid Green	Module is transmitting data. The LED flashes on for every packet. At the ControlNet data rate, the light will appear to be on continuously.
	Off	No data is being transmitted. 1. Insure the coax cable is connected. 2. Check the EIM to insure data is coming in on coax (solid green COM light). 3. Insure that all modules are securely connected together on the Interconnection BUS. 4. If everything is connected correctly, replace this module.

For OIM illustration refer to figure 5-3 above.

6
Default Settings

This chapter lists the factory default settings when an EOTec ControlNet module comes out of the box. Use this information to find out what changes may be necessary for tailoring the switch to your exact needs. For reconfiguring jumpers, consult the Device Jumpers sections of this manual.

Default Settings
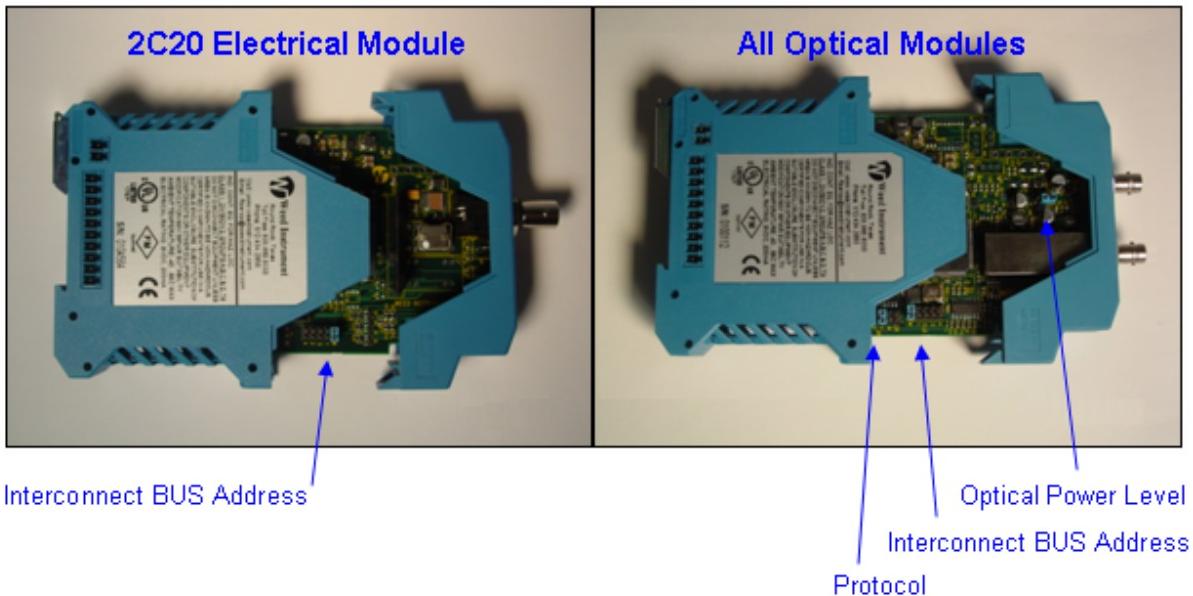
	2C20 Electrical Module	All Optical Modules
Interconnect BUS Address	M	1
Optical Power Level	n/a	H
Protocol	n/a	E

A

Technical Specifications

2C20 Electrical Interface Module (EIM)	
Maximum nodes	99 nodes supported
Maximum taps per segment	48 (using coax cable length of 250m maximum)
Maximum coax cable length	1000m (when connected to only 2 taps)
Trunk connection	Connect via ControlNet Tap with 1m drop cable required
Coax cable connection	BNC
Data rate	5M baud
Propagation Delay	800ns Maximum
Coax propagation delay	4.17µs/km; 1.27µs/1000ft
Power indicator	Green LED illuminates with power applied
Com indicator	Green LED flashes with data from the coax cable input
Mounting	35mm DIN Rail
Weight	< 9 oz. (250g)
Power input	7.5 to 9.5Vdc @ 200mA supplied from any EOTec 2000 Power Supply via the integrated BUS interconnections
Input power, maximum	1.8 W
Operating temperature range	-40 to +85 °C
Storage temperature range	-40 to +85 °C
Humidity (non-condensing)	5 to 95% RH
EMC Requirements	IEC61326-1:1998
Hazardous locations	UL/cUL and FM; Class I, Division 2, Groups A, B, C, D, T4
Packaging (polyamide)	UL 94V-0

| 2Exx/2Dxx Optical Interface Module (OIM)	
Optical Wavelength	See table 4-3 'Understanding EOTec Fiber Modules'.
Communications Data Rage	9.6K to 12 Mbps (ControlNet = 5Mbps)
Optical Port Connection	ST Compatible
Optical Dynamic Range (Optical Power Budget)	See table 4-3 'Understanding EOTec Fiber Modules'.
Propagation Delay	100ns Maximum
Fiber propagation delay	5.01µs/km; 1.53µs/1000ft
Optical Transmit Indicator	Green LED flashes with data from OIM output to fiber. (At ControlNet data rate, LED will not turn off).
Optical Receive Indicator	Amber LED flashes with data from the fiber input. (At ControlNet data rate, LED will not turn off).
Mounting	35mm DIN Rail
Weight	< 9 oz. (250g)
Power input	7.5 to 9.5Vdc @ 200mA supplied from any EOTec 2000 Power Supply via the integrated BUS interconnections
Input power, maximum	1.8 W
Operating temperature range	-40 to +85 °C
Storage temperature range	-40 to +85 °C
Humidity (non-condensing)	5 to 95% RH
EMC Requirements	IEC61326-1:1998
Hazardous locations	UL/cUL and FM; Class I, Division 2, Groups A, B, C, D, T4
Packaging (polyamide)	UL 94V-0

2A06/2A16 Power Supply Module (PSM)	
Power Requirements	90 to 260VAC, 47/440Hz at 400mA, 120 to 260VDC at 400mA
Output to Integrated BUS Interconnections	Nominal 9Vdc, 1.1A
Screw Terminals	Pluggable, cage-clamp screw terminal block accepts 12 to 24 AWG
Input Fuse	250V, 400mA, slow-blow 5 x 20mm, Littlefuse # 218.400
Relay Contact (2A16 Only)	Form-C (SPDT), 175Vdc, 1A Continuous, 0.25A Switching
Operating temperature range	-40 to +85 °C
Storage temperature range	-40 to +85 °C
Humidity (non-condensing)	5 to 95% RH
Mounting	35mm DIN Rail
Weight	< 9 oz. (250g)
Regulatory	UL/cUL Recognized
Packaging (polyamide)	UL 94V-0

| 2A08/2A18 Power Supply Module (PSM)	
Input Power Range	15 to 30VDC at 400mA
Output to Integrated BUS Interconnections	Nominal 9Vdc, 1.1A
Screw Terminals	Pluggable, cage-clamp screw terminal block accepts 12 to 24 AWG
Input Fuse	400mA, slow blow, 5 x 20mm, Littlefuse # 218.400
Relay Contact (2A16 Only)	Form-C (SPDT), 175Vdc, 1A Continuous, 0.25A Switching
Operating temperature range	-40 to +85 °C
Storage temperature range	-40 to +85 °C
Humidity (non-condensing)	5 to 95% RH
Mounting	35mm DIN Rail
Weight	< 9 oz. (250g)
Hazardous locations	UL/cUL and FM; Class I, Division 2, Groups A, B, C, D, T4
Packaging (polyamide)	UL 94V-0

Dimensions

Single Wide Modules	
Module Type	Model Number(s)
EIM	2C20
OIM	2E07, 2E09, 2E10, 2E19, 2E36, 2E46 2D07, 2D09, 2D10, 2D19, 2D36, 2D46
PSM	2A08, 2A18
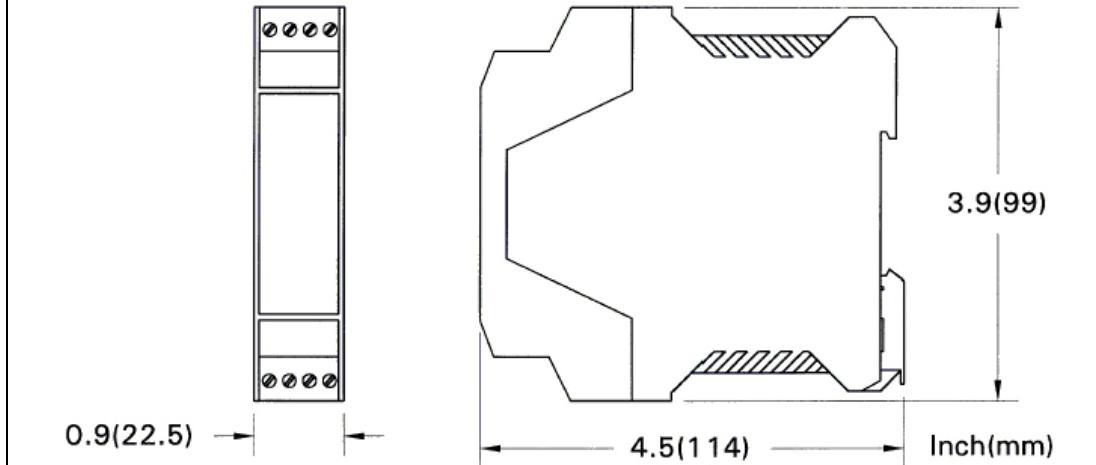
Double Wide Modules	
Module Type	Model Numbers
PSM	2A06, 2A16
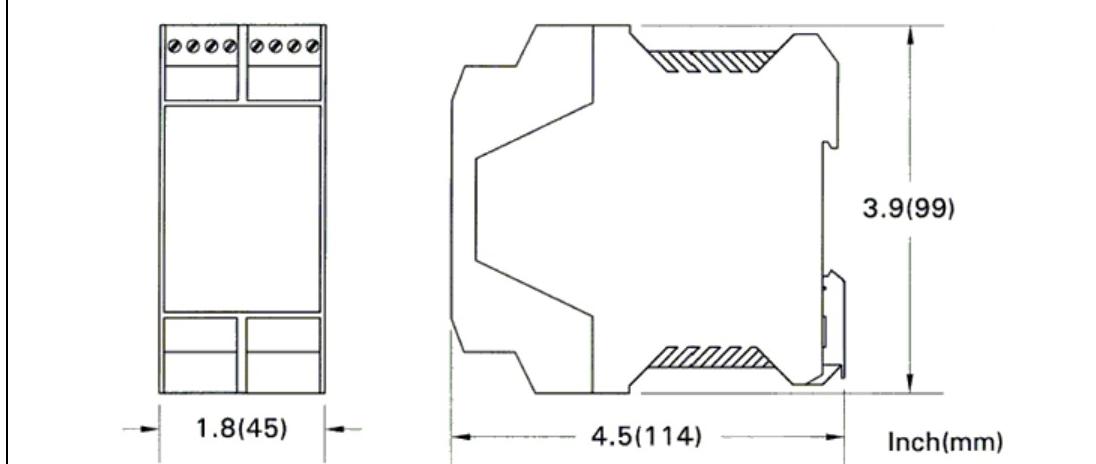
B

EOTec ControlNet Product Series

Electrical Interface Module (EIM)

Model #	Description	Connector	Qty
2C20	Electrical Interface Module, ControlNet	BNC	1

Power Supply Module (PSM)

Model #	Description	AC Voltage	DC Voltage	Connector	Qty	Alarm Relay	Connector	Qty
2A06	Power Supply Module, ControlNet	90-260VAC (47/440Hz)	120-260VDC	Cage Clamp	1			
2A16	Power Supply Module, ControlNet, Alarm	90-260VAC (47/440Hz)	120-260VDC	Cage Clamp	1	YES	Cage Clamp	1
2A08	Power Supply Module, ControlNet		24VDC	Cage Clamp	1			
2A18	Power Supply Module, ControlNet, Alarm		24VDC	Cage Clamp	1	YES	Cage Clamp	1

Optical Interface Module (OIM)

Model #	Description	Wavelength (nm)	Mode	Cable Type (µm)	Dynamic Range	Est. Dist.* (km)	Connector	Qty	Diagnostic	Connector	Qty
2E07	Optical Interface Module, ControlNet	850	MM	62.5/125	12dB	3.429	ST	2			
2D07	Optical Interface Module, ControlNet, Diagnostic	850	MM	62.5/125	12dB	3.429	ST	2	YES	Cage Clamp	1
2E10	Optical Interface Module, ControlNet, High Power	850	MM	62.5/125	17dB	4.857	ST	2			
2D10	Optical Interface Module, ControlNet, High Power, Diagnostic	850	MM	62.5/125	17dB	4.857	ST	2	YES	Cage Clamp	1
2E09	Optical Interface Module, ControlNet	1300	MM	62.5/125	12dB	8	ST	2			
2D09	Optical Interface Module, ControlNet, Diagnostic	1300	MM	62.5/125	12dB	8	ST	2	YES	Cage Clamp	1
2E19	Optical Interface Module, ControlNet, High Power	1300	MM	62.5/125	17dB	12	ST	2			
2D19	Optical Interface Module, ControlNet, High Power, Diagnostic	1300	MM	62.5/125	17dB	12	ST	2	YES	Cage Clamp	1
2E26	Optical Interface Module, ControlNet	1300	SM	9/125	10dB	20	ST	2			
2D36	Optical Interface Module, ControlNet, Diagnostic	1300	SM	9/125	10dB	20	ST	2	YES	Cage Clamp	1
2E46	Optical Interface Module, ControlNet, High Power	1300	SM	9/125	16dB	20†	ST	2			
2D46	Optical Interface Module, ControlNet, High Power, Diagnostic	1300	SM	9/125	16dB	20†	ST	2	YES	Cage Clamp	1

* The maximum length of a fiber cable section is dependent on the quality of the fiber, number of splices, and the number of connectors.

† The 2E46 is capable of much longer distances, but is constrained by the ControlNet™ maximum network limit.

C
Service Information

Technical Support and Service

For technical support, please go to our website at:
www.weedinstrument.com/contact_us/technical.html

Installation and Operation

Our professionals guide you through the installation and operation of your new product so that it is efficiently operational in the minimum amount of time. Weed Instrument also helps you install options and upgrades to ensure that your product is successfully enhanced with more performance and new capabilities.

Troubleshooting

Should you have a question regarding the operation of your instrument or its perceived malfunction, the technical support experts will help you determine the issue and offer you the best possible solution. Before contacting us, please go to our website at **www.weedinstrument.com/contact_us/tech_support/troubleshooting.html** and determine if any of the troubleshooting tips solve your problem.

Service and Repair

If you need service or repair, please go to our website at:
www.weedinstrument.com/contact_us/tech_support/service.html

1. Click the link for the RETURN MATERIAL AUTHORIZATION FORM. This must be filled out completely in order to obtain a Return Material Authorization Number (RMA#) from Weed Instrument.

2. The RMA# must be marked on the outside of the box prior to shipping the unit to us for repair or calibration.

3. You are responsible for fully decontaminating your unit prior to shipment. If we receive a contaminated product we reserve the right to have it removed and destroyed by a HAZ MAT team at the owner's expense.

4. Once the form is complete, please send to Weed Instrument by clicking on the **Submit** button. You will be given an RMA number within 24 hours. If you need the RMA# immediately, please call after sending it and a Service Administrator will give you the number verbally.

Part Number: RM0900189

Revision: 1/07